

## \* NOTICES \*

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Bibliography.

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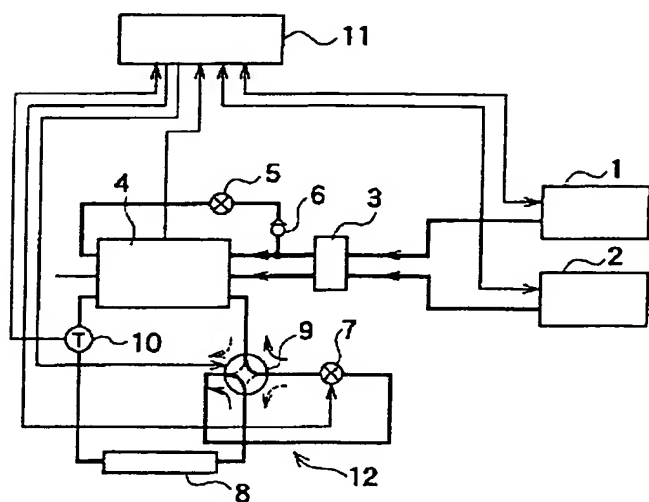
## Summary.

## (57) [Abstract]

[Technical problem] Without preparing a reference electrode in each cell of a fuel cell, a damp or wet condition is detected and operation is controlled.

[Means for Solution] The hydrogen content gas and air which were humidified with the humidifier 3 are supplied to the fuel cell stack 4 from the right-hand side in drawing. The method valve 9 of four which reverses the direction of the cooling water pump 7 made to circulate through cooling water, the radiator which radiates heat to the exterior in the heat of cooling water or a radiator, and the cooling water which flows to a radiator fan's group 8 and the fuel cell stack 4, and the thermometer 10 which measures a circulating water temperature constitute a cooling system 12. A cooling system 12 makes cooling water flow into the fuel cell stack 4 from left-hand side at the time of the cell amplitude measurement for judging a damp or wet condition, and forms a relative humidity distribution in the cell array direction. A control unit 11 judges a damp or wet condition by the cell distribution of voltage of a cell with low relative humidity, and a high cell.

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CLAIMS

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[Claim(s)]

[Claim 1] The fuel cell characterized by providing the following. A voltage detection means to detect the voltage of at least two cells chosen from two or more cells which constitute a fuel cell stack. The damp-or-wet-condition judging means which investigates the distribution of voltage for every cell which the humidity distribution means forming which forms the relative humidity distribution of fuel gas and oxidization gas in the cell array direction of a fuel cell stack at the time of the cell voltage detection by the aforementioned voltage detection means, and the aforementioned voltage detection means detected, and the voltage of a cell with low relative humidity judges as the humidity of a fuel cell being inadequate at least when low compared with the voltage of a cell with high relative humidity.

[Claim 2] It is the fuel cell according to claim 1 which carries out [ that the aforementioned humidity distribution means forming is changing to an opposite direction at the time of the voltage detection by the aforementioned voltage detection means for the damp-or-wet-condition judging by the aforementioned damp-or-wet-condition judging means, and is a cooling means form the relative-humidity distribution of fuel gas and oxidization gas in the cell array direction of a fuel cell stack while usually making the inflow direction and the circulating-water-flow close direction of a fuel cell stack of fuel gas and oxidization gas into this direction at the time of operation, and ] as the feature

[Claim 3] The aforementioned humidity distribution means forming is a fuel cell according to claim 1 which always makes an opposite direction the inflow direction and the circulating-water-flow close direction of a fuel cell stack of fuel gas and oxidization gas, and is characterized by being a cooling means to form the relative humidity distribution of fuel gas and oxidization gas in the cell array direction of a fuel cell stack.

[Claim 4] The fuel cell characterized by providing the following. A voltage amperometry means to measure the voltage and current under fuel cell stack operation. An internal resistance presumption means to presume the internal resistance value of a fuel cell stack based on the volt ampere characteristic which this voltage-current measurement means measured. A damp or wet condition judging means to judge the damp or wet condition of a fuel cell based on comparison with the standard value beforehand remembered to be the internal resistance value by which presumption was carried out [ aforementioned ]. A load limitation means to restrict the output of a fuel cell when it judges with this damp or wet condition judging means of humidity being inadequate.

[Claim 5] The fuel cell according to claim 4 characterized by having further a thermometry means to measure the temperature of a fuel cell, and a standard value change means to change the aforementioned standard value based on the measured temperature.

[Claim 6] The fuel cell characterized by providing the following. An inflow moisture-content detection means to detect the moisture content of the fuel gas which flows into a fuel cell stack, and oxidization gas. An effluent quantity detection means to detect the moisture content of the fuel gas which flows out of a fuel cell stack, and oxidization gas. A generation moisture-content presumption means to presume the moisture content generated inside the fuel cell stack. A damp or wet condition judging means to judge the damp or wet condition of a fuel cell based on

the moisture content, inflow moisture content, and effluent quantity by which generation was carried out [aforementioned].

[Claim 7] The fuel cell of the claim 1 characterized by having further a load limitation means to restrict the output of a fuel cell when it judges with the aforementioned damp or wet condition judging means of humidity being inadequate, or a claim 6 given in any 1 term.

[Claim 8] The operating method of a fuel cell characterized by providing the following. Humidity distribution formation process which forms the relative humidity distribution of fuel gas and oxidization gas in the cell array direction of a fuel cell stack. Voltage detection process in which the voltage of at least two cells chosen from two or more cells which constitute a fuel cell stack is detected. Damp or wet condition judging process which investigates the distribution of voltage for every cell, and the voltage of a cell with low relative humidity judges as the humidity of a fuel cell being inadequate when low compared with the voltage of a cell with high relative humidity. Load limitation process in which the output of a fuel cell is restricted when it judges with humidity being inadequate in the aforementioned damp or wet condition judging process.

[Claim 9] The operating method of a fuel cell characterized by providing the following. Voltage amperometry process which measures the voltage and current under fuel cell stack operation. Internal resistance presumption process in which the internal resistance value of a fuel cell stack is presumed based on the volt ampere characteristic by which measurement was carried out [aforementioned]. Damp or wet condition judging process in which the damp or wet condition of a fuel cell is judged based on comparison with the standard value beforehand remembered to be the internal resistance value by which presumption was carried out [aforementioned]. Load limitation process in which the output of a fuel cell is restricted when it judges with humidity being inadequate in the aforementioned damp or wet condition judging process.

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**DETAILED DESCRIPTION**

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to the fuel cell which can be built over the fuel cell of a solid oxide type, and its operating method, especially can control the humidity of an electrode or an electrolyte film appropriately, and its operating method.

[0002]

[Description of the Prior Art] Fuel cell technology attracts attention to the problem of the global warming by the environmental problem in recent years, especially the air pollution by exhaust gas and the carbon dioxide of an automobile as the power source which makes possible clean exhaust air and high energy efficiency, or a source of power.

[0003] The single cell of a fuel cell joins the electrode which includes a catalyst in the both sides of the electrolyte film which is an ion conductor, and is constituted. And fuel gas, oxidization gas, for example, the gas containing hydrogen, and air are supplied to two electrodes, respectively. In

the anode (fuel electrode) to which hydrogen is supplied, hydrogen ionizes into a hydrogen ion and an electron. An electron returns to an anode plate through an external circuit, and a hydrogen ion reaches a cathode (air pole) through an electrolyte film. In the cathode to which the oxygen in air is supplied, a hydrogen ion, oxygen, and an electron react and water is generated.

[0004] The theoretical electromotive force of the single cell of a fuel cell is about 1.2 V and a low, and the stack structure which usually accumulated two or more cells and was made into the series connection is used. The solid-state polyelectrolyte type fuel cell which has high power density especially also in a fuel cell attracts attention as sources for mobiles of power, such as an automobile.

[0005] In operation of such a fuel cell, an important point is keeping proper the damp or wet condition of an electrode catalyst and a solid-state polyelectrolyte film. If these tend to dry, ionic conductivity will fall and the internal resistance as a power plant will increase. If humidity passes with the generation water by the reaction of hydrogen and oxygen etc., the effective electrode area which incorporates gas will decrease and the output current will decrease.

[0006] It considers as the technology which controls the damp or wet condition of the electrode in the conventional fuel cell, and a solid-state polyelectrolyte film proper, and technology given in JP,7-22047,A is known. According to this conventional technology, the reference electrode which shows the reference potential stabilized in the fuel cell was prepared, the anode of a cell to this reference electrode and the potential of a cathode were measured, and the amount of humidification of fuel gas or oxidization gas was adjusted based on this potential.

[0007]

[Problem(s) to be Solved by the Invention] However, since the above-mentioned conventional technology had become the composition of measuring the potential of the anode to the reference electrode in a fuel cell, and a cathode, there was a trouble that application was impossible in the fuel cell which does not have the reference electrode.

[0008] Moreover, since the above-mentioned conventional technology had become the composition of judging the excess of moisture, or dryness of a film, by change of the anode to the output current, and cathode potential, when the above output current was not pulled out to some extent, a unique reaction was not seen but it had the trouble that the judgment of a damp or wet condition was difficult.

[0009] Furthermore, since both the excess of moisture and dryness of a film may become a cause when the singularity of potential change is accepted in an anode and cathode two poles, the above-mentioned conventional technology requires time for both distinction. It was specifically made dryness at once, and after measuring the potential change, since both distinction was judged, the trouble that immediate output recovery was difficult was for the first time.

[0010] It is offering the fuel cell which detects a damp or wet condition and can control operation, and its operating method, without the purpose of this invention preparing a reference electrode in each cell of a fuel cell in view of the above trouble.

[0011] Moreover, especially the purpose of this invention is offering the fuel cell which can judge a damp or wet condition easily, and its operating method, without pulling out the output current of a fuel cell.

[0012] Furthermore, the purpose of this invention is offering the fuel cell which can judge easily whether it having changed in the overhydration or which direction of dryness from the proper damp or wet condition, and its operating method.

[0013]

[Means for Solving the Problem] A voltage detection means to detect the voltage of at least two cells chosen from two or more cells which constitute a fuel cell stack in order that invention according to claim 1 might solve the above-mentioned technical problem, The humidity distribution means forming which forms the relative humidity distribution of fuel gas and oxidization gas in the cell array direction of a fuel cell stack at least at the time of the cell voltage detection by the voltage detection means, The distribution of voltage for every cell which the voltage detection means detected is investigated, and relative humidity is [ the voltage of a

low cell ] the fuel cell which makes it a summary to have had a damp or wet condition judging means to judge with the humidity of a fuel cell being inadequate to a low case compared with the voltage of a cell with high relative humidity.

[0014] Invention according to claim 2 is set to a fuel cell according to claim 1 in order to solve the above-mentioned technical problem. the aforementioned humidity distribution means forming While usually making the inflow direction and the circulating-water-flow close direction of a fuel cell stack of fuel gas and oxidization gas into this direction at the time of operation Let it be a summary to be a cooling means to form the relative humidity distribution of fuel gas and oxidization gas in the cell array direction of a fuel cell stack by changing to an opposite direction at the time of the voltage detection by the aforementioned voltage detection means for the damp or wet condition judging by the aforementioned damp or wet condition judging means.

[0015] In order that invention according to claim 3 may solve the above-mentioned technical problem, in a fuel cell according to claim 1, the aforementioned humidity distribution means forming always makes an opposite direction the inflow direction and the circulating-water-flow close direction of a fuel cell stack of fuel gas and oxidization gas, and makes it a summary to be a cooling means to form the relative humidity distribution of fuel gas and oxidization gas in the cell array direction of a fuel cell stack.

[0016] A voltage amperometry means to measure the voltage and current under fuel cell stack operation in order that invention according to claim 4 may solve the above-mentioned technical problem, An internal resistance presumption means to presume the internal resistance value of a fuel cell stack based on the volt ampere characteristic which this voltage-current measurement means measured, It is the fuel cell which makes it a summary to have had a damp or wet condition judging means to judge the damp or wet condition of a fuel cell, based on comparison with the standard value beforehand remembered to be this presumed internal resistance value.

[0017] Invention according to claim 5 makes it a summary to have had further a thermometry means to measure the temperature of a fuel cell, and a standard value change means to change the aforementioned standard value based on the measured temperature in a fuel cell according to claim 4 in order to solve the above-mentioned technical problem.

[0018] An inflow moisture-content detection means to detect the moisture content of the fuel gas which flows into a fuel cell stack, and oxidization gas in order that invention according to claim 6 may solve the above-mentioned technical problem, An effluent quantity detection means to detect the moisture content of the fuel gas which flows out of a fuel cell stack, and oxidization gas, It is the fuel cell which makes it a summary to have had a generation moisture-content presumption means to presume the moisture content generated inside the fuel cell stack, and a damp or wet condition judging means to judge the damp or wet condition of a fuel cell based on the moisture content, inflow moisture content, and effluent quantity by which generation was carried out [ aforementioned ].

[0019] When it judges with the aforementioned damp or wet condition judging means of humidity being inadequate in the fuel cell of a claim 1 or a claim 6 given in any 1 term, invention according to claim 7 makes it a summary to have had further a load limitation means to restrict the output of a fuel cell, in order to solve the above-mentioned technical problem.

[0020] The humidity distribution morphosis which forms the relative humidity distribution of fuel gas and oxidization gas in the cell array direction of a fuel cell stack in order that invention according to claim 8 may solve the above-mentioned technical problem, Voltage detection process in which the voltage of at least two cells chosen from two or more cells which constitute a fuel cell stack is detected, When the distribution of voltage for every cell is investigated and the voltage of a low cell judges [ relative humidity / relative humidity ] with humidity being inadequate in the damp or wet condition judging process judged as the humidity of a fuel cell being inadequate to a low case compared with the voltage of a high cell, and this damp or wet condition judging process, It is the operating method of the fuel cell which makes it a summary to have had load limitation process in which the output of a fuel cell was restricted.

[0021] The voltage amperometry process which measures the voltage and current under fuel cell stack operation in order that invention according to claim 9 may solve the above-mentioned technical problem, Internal resistance presumption process in which the internal resistance value

of a fuel cell stack is presumed based on this measured volt ampere characteristic, When it judges with humidity being inadequate based on comparison with the standard value beforehand remembered to be this presumed internal resistance value in damp or wet condition judging process in which the damp or wet condition of a fuel cell is judged, and this damp or wet condition judging process, It is the operating method of the fuel cell which makes it a summary to have had load limitation process in which the output of a fuel cell was restricted.

[0022]

[Effect of the Invention] A voltage detection means to detect the voltage of at least two cells which were chosen from two or more cells which constitute a fuel cell stack according to invention according to claim 1, The humidity distribution means forming which forms the relative humidity distribution of fuel gas and oxidization gas in the cell array direction of a fuel cell stack at least at the time of the cell voltage detection by the aforementioned voltage detection means, Since the distribution of voltage for every cell which the aforementioned voltage detection means detected was investigated, and the voltage of a cell with low relative humidity was equipped with a damp or wet condition judging means to judge with the humidity of a fuel cell being inadequate when low compared with the voltage of a cell with high relative humidity The effect that it can judge correctly whether overmoisture and the moisture of the damp or wet condition of a fuel cell are insufficient based on the measurement result of the voltage of a cell with high relative humidity and the voltage of a cell with low relative humidity is done so. Moreover, since the judgment of a damp or wet condition becomes exact, an unnecessary hydrogen purge is reduced and the effect of improving the mpg of a fuel cell is done so.

[0023] According to invention according to claim 2, to an effect of the invention according to claim 1 in addition, the aforementioned humidity distribution means forming While usually making the inflow direction and the circulating-water-flow close direction of a fuel cell stack of fuel gas and oxidization gas into this direction at the time of operation By changing to an opposite direction at the time of the voltage detection by the aforementioned voltage detection means for the damp or wet condition judging by the aforementioned damp or wet condition judging means Since it is a cooling means to form the relative humidity distribution of fuel gas and oxidization gas in the cell array direction of a fuel cell stack Usually, the effect that an exact damp or wet condition can be judged is done so, without forming a relative humidity distribution of the both sides of a relative humidity distribution suitable at the time of operation and a relative humidity distribution suitable at the time of a damp or wet condition judging, and usually reducing the generating efficiency at the time of operation.

[0024] According to invention according to claim 3, to an effect of the invention according to claim 1 in addition, the aforementioned humidity distribution means forming Since the inflow direction and the circulating-water-flow close direction of a fuel cell stack of fuel gas and oxidization gas were always made into the opposite direction and it is a cooling means to form the relative humidity distribution of fuel gas and oxidization gas in the cell array direction of a fuel cell stack The effect that an exact damp or wet condition can be judged is done so, without preparing the circulating-water-flow close direction change function, and complicating a cooling means.

[0025] A voltage amperometry means to measure the voltage and current under fuel cell stack operation according to invention according to claim 4, An internal resistance presumption means to presume the internal resistance value of a fuel cell stack based on the volt ampere characteristic which this voltage-current measurement means measured, The effect that a damp or wet condition can be judged is done so, without forming a relative humidity distribution in a fuel cell stack, since it had a damp or wet condition judging means to judge the damp or wet condition of a fuel cell, based on comparison with the standard value beforehand remembered to be the internal resistance value by which presumption was carried out [ aforementioned ].

[0026] since it had [ according to invention according to claim 5 ] further a thermometry means to measure the temperature of a fuel cell, and a standard value change means to change the aforementioned standard value based on the measured temperature in addition to the effect of the invention according to claim 4, even if the operating temperature of a fuel cell has change, the effect that an exact damp or wet condition judging can be performed is done so



[0027] An inflow moisture-content detection means to detect the moisture content of the fuel gas which flows into a fuel cell stack, and oxidization gas according to invention according to claim 6, An effluent quantity detection means to detect the moisture content of the fuel gas which flows out of a fuel cell stack, and oxidization gas, By having had a generation moisture-content presumption means to presume the moisture content generated inside the fuel cell stack, and a damp or wet condition judging means to judge the damp or wet condition of a fuel cell based on the moisture content, inflow moisture content, and effluent quantity by which generation was carried out [ aforementioned ] The change history of the moisture content inside a fuel cell stack is pursued correctly, and the effect that the damp or wet condition of a fuel cell can be judged correctly is done so.

[0028] since it had further a load limitation means to restrict the output of a fuel cell when it judged [ according to invention according to claim 7 ] with the aforementioned damp or wet condition judging means of humidity being inadequate in addition to a claim 1 or an effect of the invention according to claim 6, the effect that recovery from dryness and continuation of operation of a fuel cell can be reconciled is done so

[0029] The humidity distribution morphosis which forms the relative humidity distribution of fuel gas and oxidization gas in the cell array direction of a fuel cell stack according to invention according to claim 8, Voltage detection process in which the voltage of at least two cells chosen from two or more cells which constitute a fuel cell stack is detected, When the distribution of voltage for every cell is investigated and the voltage of a low cell judges [ relative humidity / relative humidity ] with humidity being inadequate in the damp or wet condition judging process judged as the humidity of a fuel cell being inadequate to a low case compared with the voltage of a high cell, and the aforementioned damp or wet condition judging process, Since it had load limitation process in which the output of a fuel cell was restricted, the effect that it can judge correctly whether the overhydration or the moisture of the damp or wet condition of a fuel cell is insufficient based on the measurement result of the voltage of a cell with high relative humidity and the voltage of the low cell of relative humidity is done so. Moreover, since the judgment of a damp or wet condition becomes exact, an unnecessary hydrogen purge is reduced and the effect of improving the mpg of a fuel cell is done so.

[0030] The voltage amperometry process which measures the voltage and current under fuel cell stack operation according to invention according to claim 9, Internal resistance presumption process in which the internal resistance value of a fuel cell stack is presumed based on the volt ampere characteristic by which measurement was carried out [ aforementioned ], When it judges with humidity being inadequate based on comparison with the standard value beforehand remembered to be the internal resistance value by which presumption was carried out

[ aforementioned ] in damp or wet condition judging process in which the damp or wet condition of a fuel cell is judged, and the aforementioned damp or wet condition judging process, The effect that a damp or wet condition can be judged is done so, without forming a relative humidity distribution in a fuel cell stack, since it had load limitation process in which the output of a fuel cell was restricted. Moreover, since the judgment of a damp or wet condition becomes exact, an unnecessary hydrogen purge is reduced and the effect of improving the mpg of a fuel cell is done so.

[0031]

[Embodiments of the Invention] Next, with reference to a drawing, the gestalt of operation of this invention is explained in detail.

[1st operation gestalt] Drawing 1 is a whole block diagram explaining the composition of the 1st operation gestalt of the fuel cell concerning this invention. The hydrogen feed zone 1 which supplies the gas (following and hydrogen content gas) by which a fuel cell contains the hydrogen as fuel gas by desired pressure and flow rate in drawing 1, The air supply section 2 which supplies the air as oxidization gas by desired pressure and flow rate, The humidifier 3 which humidifies hydrogen content gas and air with the pure water supplied from the pure water feeder which is not illustrated, respectively, The fuel cell stack 4 to which the hydrogen content gas and air which were humidified with the humidifier 3 are supplied, While cooling the pump 5 for fuel circulation which makes the hydrogen which was not used recycle, the check valve 6 which



prevents the adverse current of hydrogen content gas, and the fuel cell stack 4. At the time of the amplitude measurement for a damp or wet condition judging, it has the cooling system 12 which can make an opposite direction the inflow direction of the cooling water to the fuel cell stack 4 with the gas-stream close direction to the fuel cell stack 4, and the control unit 11 which controls these equipments.

[0032] The voltage detector which are two or more cells chosen from two or more cells which constitute a stack, and a voltage detection means to detect each voltage of all cells preferably and which is not illustrated is formed in the fuel cell stack 4, and the detecting signal of this voltage detector is told to it to a control unit 11.

[0033] A cooling system 12 is equipped with the circulating-water-flow way which was established in the interior of the fuel cell stack 4 and which is not illustrated, the cooling water pump 7 made to circulate through cooling water, the radiator or the radiator which radiates heat to the exterior in the heat of cooling water, and a radiator fan's group 8, the method valve 9 of four which reverses the direction of the cooling water which flows to the fuel cell stack 4, the thermometer 10 which measures a circulating water temperature, the duct which connects these, and the cooling water with which these interior

[0034] And the cooling system 12 constitutes the humidity distribution means forming which forms the relative humidity distribution of fuel gas and oxidization gas in the cell array direction of a fuel cell stack at the time of the cell voltage detection by the voltage detection means.

[0035] Moreover, while a control unit 11 receives the hydrogen feed zone 1, the air supply section 2, and the detecting signal from a thermometer 10, it sends out the hydrogen feed zone 1, the air supply section 2, a cooling water pump 7, and the control signal that controls the method valve 9 of four.

[0036] Next, an operation of the relative humidity distribution formation by the cooling system 12 is explained. The hydrogen content gas and air which are supplied from the hydrogen feed zone 1 and the air supply section 2 are supplied from the right-hand side in drawing of the fuel cell stack 4, after passing a humidifier 3 and becoming suitable humidity. It is thought that absolute humidity does not fall and absolute humidity goes up them rather since this hydrogen content gas and air are further humidified by the moisture which generates the interior of the fuel cell stack 4 by power generation as it flows from the right to the left after they are humidified by a certain absolute humidity with a humidifier 3.

[0037] According to the control from a control unit 11, usually, at the time of operation, the method valve 9 of four which changes the direction of cooling water pours cooling water in the direction of an arrow of a solid line, and at the time of the voltage detection by the voltage detector, it changes it so that cooling water may be poured in the direction of an arrow of a dashed line. Since the cooling water which flows the fuel cell stack 4 by this usually flows from drawing Nakamigi to the left at the time of operation, the temperature distribution in the fuel cell stack 4 at this time have the low right-hand side in drawing, and left-hand side becomes high.

[0038] On the other hand, since cooling water flows from \*\*\*\*\* to the right contrary to the direction where gas flows, at the time of the amplitude measurement for a damp or wet condition judging, the temperature distribution in the fuel cell stack 4 at this time usually have the high right-hand side in drawing contrary to the time of operation, and left-hand side becomes low at it. Therefore, the relative humidity distribution of the fuel cell stack 4 at the time of an amplitude measurement has the low right-hand side in drawing, and left-hand side becomes high.

[0039] Where such a relative humidity distribution is formed, when each temperature of two or more cells of the fuel cell stack 4 is measured, according to the position of the measured cell, the voltage of the low cell of relative humidity and the voltage of a cell with high relative humidity will be measured.

[0040] In addition, a relative humidity distribution may always be made to be formed in a fuel cell stack by making the gas-stream close direction to a fuel cell stack, and the direction of a cooling water close style into opposite direction as a modification of the 1st operation gestalt, without usually changing the direction of cooling water in the time of operation and the amplitude measurement for a damp or wet condition judging. According to this modification, although it becomes the composition which omits the method valve of four which changes the direction of

cooling water, and is shown in drawing 2 , it is unavoidable that some falls usually arise in the generating efficiency at the time of operation.

[0041] Next, operation of the 1st operation gestalt is explained with reference to the flow chart of drawing 3 . The current under fuel cell stack operation and detection of voltage are first performed at Step (a step is hereafter abbreviated to S) 101. Subsequently, in S102, it returns to S101 again, without carrying out the processing flow of this operation gestalt shown in less than [ S103 ], if it judges whether sag is carried out and sag is not accepted from the current-potential property of having memorized beforehand the combination of this detected current/voltage.

[0042] When sag is accepted, it supposes that voltage should be recovered appropriately that it is necessary to judge the cause of sag with a sufficient precision, and with this operation gestalt, the method valve 9 of four is changed so that the circulation direction of cooling water may turn into the I/O direction to the fuel cell stack 4 of gas, such as hydrogen and air, by S103 at an opposite direction. Of the change of this circulating-water-flow close direction, the distribution of relative humidity is formed in the cell array direction as mentioned above in the fuel cell stack 4.

[0043] In addition, like the modification of the 1st operation gestalt shown in drawing 2 , the inflow direction of the cooling water to a fuel cell stack is always set as an opposite direction with the inflow direction of gas, and when it has composition which does not change the circulating-water-flow close direction, these S103 is omitted.

[0044] Moreover, when the existence of sag is judged and sag is judged, although [ S102 ] below this step is performed, it is good also as composition which deletes S101 and S102 and performs processing not more than S103 periodically.

[0045] Subsequently, where the distribution of relative humidity is formed in the cell array direction, a voltage detector detects the voltage of each cell which constitutes a fuel cell stack from S104, and a detection value is told to a control unit 11. It is more desirable to consider cell voltage of these plurality as the composition which can detect the value of the same time as much as possible, although the fuel cell stack 4 consisted of two or more cells.

[0046] Subsequently, in S105, the inclination of the cell voltage by the position of each cell is judged, and it judges whether it is what the cause of sag depends on dryness of a film by S106.

[0047] Although drawing 4 is an example of the cell distribution of voltage corresponding to each cell position, it is drawing which arranged the voltage of each cell in order and expressed it toward the outlet side from the gas inlet side. It will judge, if a film does not fully carry out humidity but is in dryness, when the inclination for it to apply to an outlet side from a gas inlet side, and for cell voltage to become high like this drawing 4 is acquired.

[0048] It is possible to judge that this means that the voltage of the cell of the low portion of relative humidity is lower than the voltage of a cell with high relative humidity, namely, the film of the cell of the low portion of relative humidity does not fully carry out humidity, but it causes [ of voltage ] a fall.

[0049] Moreover, although it is the case where correlation is not looked at by the distribution of relative humidity, and especially the distribution of cell voltage when cell distribution of voltage as shown in drawing 5 is obtained namely, it is judged that humidity of the film is fully carried out in this case. In the state where there is no correlation in cell voltage and relative humidity, rather than expected value, the film is not dry as a low and cell voltage may judge it as what is depended on other causes, for example, the fall of a hydrogen partial pressure etc.

[0050] In addition, although it is the case where a distribution whose cell voltage of a portion with the high relative humidity by the side of a gas inlet is low to the cell voltage of the low portion of the relative humidity by the side of a gas outlet is obtained when a distribution as shown in drawing 6 in this operation gestalt is obtained namely, moisture accumulates in the cell of a portion with high relative humidity in this case, and if voltage is falling by reduction of reaction area, it can judge.

[0051] As mentioned above, when the cause of sag is judged to be what is depended on dryness of a film, a fuel cell stack output is restricted and the upper limit in which an output demand is possible is notified to the control means (not shown) of the high order which controls (S107-

109), simultaneously orders it the output demand of a fuel cell stack to the fuel cell control means 11 so that it may not become below the set point with stack voltage.

[0052] Thereby, since the operation of a demand instruction value is attained recognizing the maximum of the power which a fuel cell stack can take out, the control means of a high order can prevent the state of saying that it is not outputted unexpectedly.

[0053] In addition, the result which presumed the membranous damp or wet condition according to the inclination according to the position of each cell voltage like S104-S106 may perform load limitation of a fuel cell stack.

[0054] Moreover, although it is the voltage of a fuel cell stack, and the control means of an output, it may connect with a fuel cell stack, a DC to DC converter with a current control function may be carried out, and, for details, it omits.

[0055] Moreover, when the cause of sag is except dryness of a film, the block which performs processing corresponding to the cause is performed. For example, when nitrogen concentration goes up to a hydrogen pole side and the hydrogen partial pressure is falling as a result, it controls to raise a hydrogen partial pressure by purging a hydrogen pole (S110).

[0056] As an example, when hydrogen is the circulatory system, although a hydrogen pole purge is possible, since it is not the essence of this invention, it omits for details by discharging to the system exterior, without returning \*\*\*\*\* from a fuel cell stack, and increasing a hydrogen flow rate simultaneously.

[0057] [2nd operation gestalt] The composition of this operation gestalt is the same as that of drawing 1 which shows the 1st operation gestalt. In addition, in this operation gestalt, since it is not necessary to necessarily make reverse the inflow direction of gas, and the inflow direction of cooling water, the method valve 9 of four is omissible.

[0058] The flow chart of this operation gestalt is shown in drawing 7. This operation gestalt measures the current and voltage of a fuel cell stack on stream more than a certain fixed time or more than the certain fixed number of samplings, calculates the current and the voltage shell internal resistance value which were measured, and presumes membranous dryness from the value.

[0059] It is equivalent to the inclination of the interstitial segment in the current-voltage characteristic indicated to be an internal resistance value here to drawing 10 (a). Ionic conductivity falls and it is observed in a form like increase of electric resistance as a membranous moisture content decreases.

[0060] namely, — if humidity is carried out enough, although it will become the property (it considers as a standard property hereafter) which shows the highest voltage in drawing 10 (a), the voltage when pulling out the same current value from a fuel cell stack falls, and the inclination of an abbreviation bay is sudden as it becomes with some dryness — becoming — a result — a form [ like the lower left ] whose current-voltage characteristic is — changing —  
\*\*\*\*\*.

[0061] Moreover, to the current which the state (a flow rate and pressure) of gas took out, although the membranous damp or wet condition is suitable when more than a certain current value is taken out and the fall of voltage is accepted rapidly (drawing 10 (b)), although the inclination of this abbreviation bay was the same as it of a standard property, if not suitable, it will judge.

[0062] Moreover, it can be judged that it becomes the volt ampere characteristic when the state of drawing 10 (a) and drawing 10 (b) occurs simultaneously, as shown in drawing 10 (c), and membranous humidity is liable to insufficient, and the state of gas is not suitable when the inclination of an abbreviation bay is more sudden than a standard property, and more than a certain current value is taken out, a property separates from a straight line and voltage falls.

[0063] The flow chart of drawing 7 which asks below for internal resistance based on the volt ampere characteristic measured on stream [ a fuel cell stack ] is explained.

[0064] The current and voltage of a fuel cell stack of \*\*\*\* time are first detected by S201. This time of this timing is as much as possible more desirable. Subsequently, in S202, data are filtered with the value of the detected current. Very much, since the influence of internal resistance has not come out of the property in a small current region, this is for cutting the data of such a field.

In S203, in order to refer to by the internal resistance operation mentioned later, the measured current and the group data of voltage are recorded on a record means.

[0065] In S204, the recorded current and the group data of voltage judge whether it is sufficient thing for internal resistance calculation. It may be recorded more than the set point that has that current value is scattered enough broadly and the number of group data as conditions judge that are enough. In S205, internal resistance is actually calculated. Specifically, two or more current and the group data of voltage are approximated in a straight line, and it asks for them from the slope of a line.

[0066] In addition, about the method of approximating the group data of two or more current/voltage in a straight line, there are a least-squares method which asks for the approximation straight line from which the sum total of the square of the distance from the point which shows class data to an approximation straight line serves as the minimum, a method shown in JP,6-174808,A.

[0067] The inclination of the abbreviation bay for which it asked by the above methods is compared with the standard property beforehand searched for in the experiment etc., when an inclination is sudden, it judges that the film is dry, and it processes [ restricting an output etc. and ], and it becomes possible to stop bad influences, such as degradation of a stack. moreover, the inclination of an abbreviation bay — it of a standard property, and abbreviation — it is the same, and the nitrogen accumulated by performing purge processing on the hydrogen pole is discharged, a hydrogen partial pressure is recovered [ it supposes that a problem is in gas conditions when the fall of voltage is accepted in more than a certain current value, and ], and it becomes possible to return to the standard property of voltage

[0068] In addition, since the internal resistance of a fuel cell has the temperature characteristics, such as resistance of an electrode, and electrolytic ion conductivity, it is desirable to change the standard value of internal resistance according to the measurement result of the thermometer 10 which measures cooling water temperature, for example. The map for which it specifically asked experimentally, and an amendment formula are used.

[0069] [3rd operation gestalt] Drawing 8 is the whole block diagram showing the composition of the 3rd operation gestalt of the fuel cell concerning this invention. This operation gestalt is the example which deleted the method valve 9 of four, made the circulating-water-flow close direction to the fuel cell stack 4 always the same as that of the gas-stream close direction to the 1st operation gestalt shown in drawing 1, and prepared the moisture flow rate detection means in hydrogen content gas and the fuel cell stack I/O section of air.

[0070] That is, a moisture flow rate detection means 21 to detect the moisture flow rate which flows into the fuel cell stack 4 from the hydrogen feed zone 1, a moisture flow rate detection means 22 detect the moisture flow rate which flows out of a hydrogen outlet, a moisture flow rate detection means 23 detect the moisture flow rate which flows from the air supply section 2, and a moisture flow rate detection means 24 detect the moisture flow rate which is an air outlet and which carries out a shell outflow have been established. As these moisture flow rate detection meanses 21, 22, 23, and 24, it is possible to constitute, for example from a dew-point detection means and mass flow rate detection meanses, such as a mirror-plane cooling formula.

[0071] Moreover, in the control unit 11, a means to calculate the moisture content generated inside the fuel cell stack according to the current value taken out from the fuel cell stack 4 is established.

[0072] To the value which added the moisture content generated inside the stack by the moisture flow rate sum total in the hydrogen of the entrance of the fuel cell stack 4, and air, if the moisture flow rate sum total in the hydrogen of a fuel cell stack outlet and air is large, it is shown that having come out from a film into the gas of moisture is shown, namely, a film is in a dryness inclination.

[0073] Conversely, if the hydrogen of an outlet and the moisture-content sum total in air are small, it turns out that moisture will have permeated the film out of gas, namely, a film is in a humid inclination. Therefore, the average humid grade in a fuel cell stack can be presumed now by integrating with the variation of this moisture.

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[Translation done.]

\* NOTICES \*

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- 1.This document has been translated by computer. So the translation may not reflect the original precisely.
- 2.\*\*\*\* shows the word which can not be translated.
- 3.In the drawings, any words are not translated.

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DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is the whole block diagram showing the composition of the 1st operation gestalt of the fuel cell concerning this invention.

[Drawing 2] It is the whole block diagram showing the composition of the modification of the 1st operation gestalt.

[Drawing 3] It is a flow chart explaining operation of the 1st operation gestalt.

[Drawing 4] It is drawing showing the example of cell distribution of voltage over the cell position in an inadequate damp or wet condition.

[Drawing 5] It is drawing showing the example of cell distribution of voltage over the cell position in a moderate damp or wet condition.

[Drawing 6] It is drawing showing the example of cell distribution of voltage over the cell position in a superfluous damp or wet condition.

[Drawing 7] It is a flow chart explaining operation of the 2nd operation gestalt.

[Drawing 8] It is the whole block diagram showing the composition of the 3rd operation gestalt of the fuel cell concerning this invention.

[Drawing 9] (a) When the moisture in a film decreases and (b) hydrogen partial pressure falls, it is drawing which is the case where a hydrogen partial pressure falls after the moisture in the (c) film had decreased and in which showing the example of representation of the current-voltage characteristic of a fuel cell, respectively.

[Description of Notations]

- 1 Hydrogen Feed Zone
- 2 Air Supply Section
- 3 Humidifier
- 4 Fuel Cell Stack
- 5 Pump for Fuel Circulation
- 6 Check Valve
- 7 Cooling Water Pump
- 8 Radiator
- 9 Method Valve of Four
- 10 Thermometer
- 11 Control Unit
- 12 Cooling System

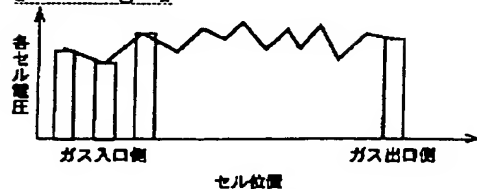
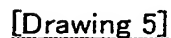
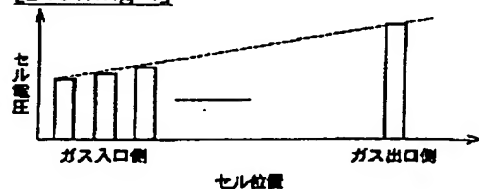
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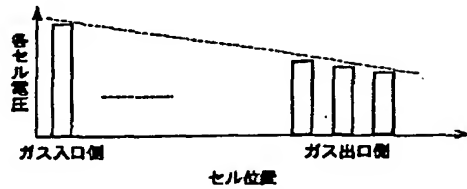
\* NOTICES \*

**3. In the drawings, any words are not translated.**

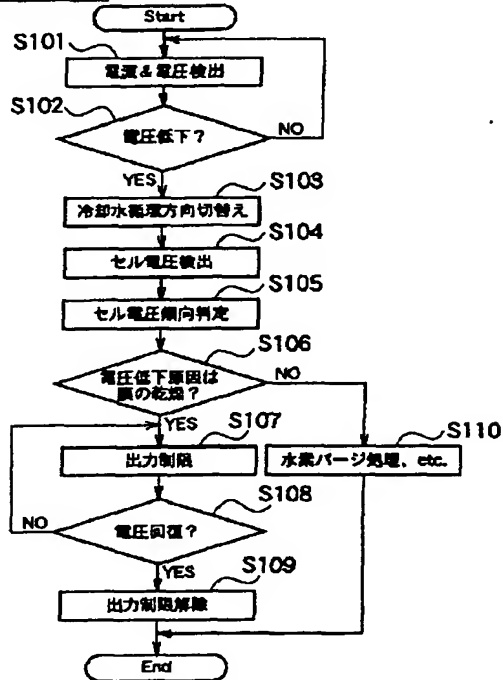
[Drawing 1]



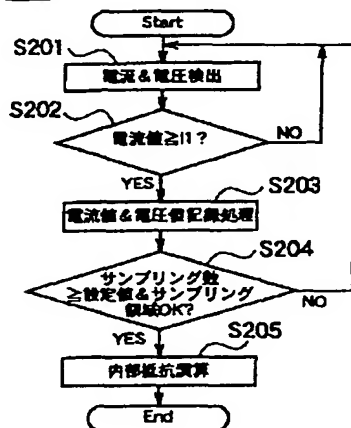
[Drawing 6]



[Drawing 3]

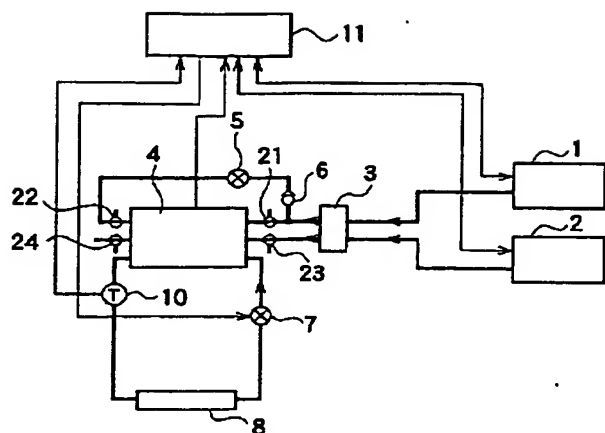


[Drawing 7]

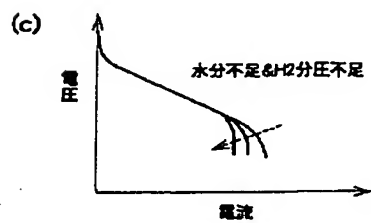
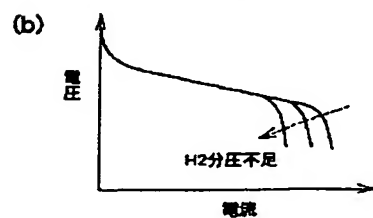
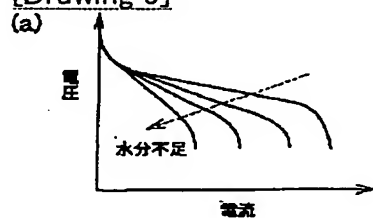


[Drawing 8]





[Drawing 9]



[Translation done.]

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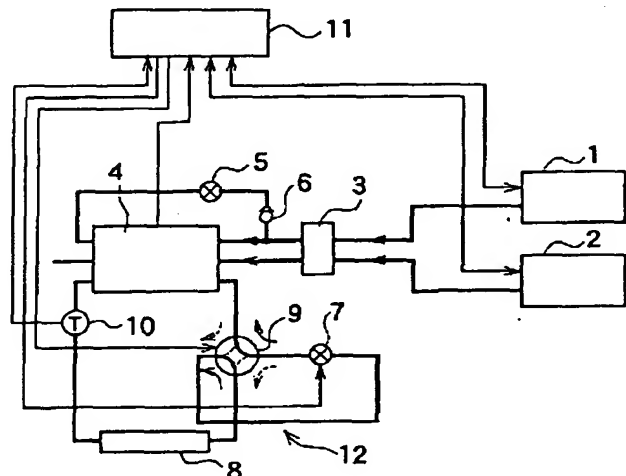
KK56 MM16 MM26

(54) 【発明の名称】 燃料電池及びその運転方法

(57) 【要約】

【課題】 燃料電池の各セルに参照電極を設けることなく、湿潤状態を検出して運転を制御する。

【解決手段】 燃料電池スタック4には加湿器3で加湿された水素含有ガス及び空気が図中右側から供給される。冷却水を循環させる冷却水ポンプ7、冷却水の熱を外部へ放熱するラジエータまたはラジエータとラジエータファンの組8、燃料電池スタック4に流れる冷却水の流れを反転させる4方弁9、及び冷却水温度を測定する温度計10は冷却系12を構成する。冷却系12は、湿潤状態を判定するためのセル電圧測定時には左側から燃料電池スタック4へ冷却水を流入させ、セル配列方向に相対湿度分布を形成する。制御装置11は、相対湿度の低いセルと高いセルとのセル電圧分布により、湿潤状態を判定する。



## 【特許請求の範囲】

【請求項1】 燃料電池スタックを構成する複数のセルから選ばれた少なくとも2つのセルの電圧を検出する電圧検出手段と、

少なくとも前記電圧検出手段によるセル電圧検出時に、燃料電池スタックのセル配列方向に燃料ガス及び酸化ガスの相対湿度分布を形成する湿度分布形成手段と、前記電圧検出手段が検出した各セル毎の電圧分布を調べて、相対湿度が低いセルの電圧が相対湿度が高いセルの電圧に比べて低い場合に、燃料電池の湿潤が不十分と判定する湿潤状態判定手段と、を備えたことを特徴とする燃料電池。

【請求項2】 前記湿度分布形成手段は、燃料ガス及び酸化ガスの燃料電池スタックへの流入方向と冷却水流入方向とを通常運転時には同方向とする一方、前記湿潤状態判定手段による湿潤状態判定のための前記電圧検出手段による電圧検出時には逆方向に切り替えることで、燃料電池スタックのセル配列方向に燃料ガス及び酸化ガスの相対湿度分布を形成する冷却手段であることを特徴とする請求項1記載の燃料電池。

【請求項3】 前記湿度分布形成手段は、燃料ガス及び酸化ガスの燃料電池スタックへの流入方向と冷却水流入方向とを常に逆方向とし、燃料電池スタックのセル配列方向に燃料ガス及び酸化ガスの相対湿度分布を形成する冷却手段であることを特徴とする請求項1記載の燃料電池。

【請求項4】 燃料電池スタック運転中の電圧と電流とを測定する電圧電流測定手段と、該電圧電流測定手段が測定した電圧電流特性に基づいて、燃料電池スタックの内部抵抗値を推定する内部抵抗推定手段と、前記推定された内部抵抗値と予め記憶した標準値との比較に基づいて、燃料電池の湿潤状態を判定する湿潤状態判定手段と、該湿潤状態判定手段が湿潤が不十分と判定したとき、燃料電池の出力を制限する出力制限手段と、を備えたことを特徴とする燃料電池。

【請求項5】 燃料電池の温度を測定する温度測定手段と、測定された温度に基づいて前記標準値を変更する標準値変更手段と、を更に備えたことを特徴とする請求項4記載の燃料電池。

【請求項6】 燃料電池スタックへ流入する燃料ガス及び酸化ガスの水分量を検出する流入水分量検出手段と、燃料電池スタックから流出する燃料ガス及び酸化ガスの水分量を検出する流出水分量検出手段と、燃料電池スタック内部で生成された水分量を推定する生成水分量推定手段と、前記生成された水分量及び流入水分量及び流出水分量に

基づいて燃料電池の湿潤状態を判定する湿潤状態判定手段と、

を備えたことを特徴とする燃料電池。

【請求項7】 前記湿潤状態判定手段が湿潤が不十分と判定したとき、燃料電池の出力を制限する出力制限手段を更に備えたことを特徴とする請求項1ないし請求項6のいずれか1項記載の燃料電池。

【請求項8】 燃料電池スタックのセル配列方向に燃料ガス及び酸化ガスの相対湿度分布を形成する湿度分布形成過程と、燃料電池スタックを構成する複数のセルから選ばれた少なくとも2つのセルの電圧を検出する電圧検出過程と、各セル毎の電圧分布を調べて、相対湿度が低いセルの電圧が相対湿度が高いセルの電圧に比べて低い場合に、燃料電池の湿潤が不十分と判定する湿潤状態判定過程と、前記湿潤状態判定過程で湿潤が不十分と判定したとき、燃料電池の出力を制限する出力制限過程と、を備えたことを特徴とする燃料電池の運転方法。

【請求項9】 燃料電池スタック運転中の電圧と電流とを測定する電圧電流測定過程と、前記測定された電圧電流特性に基づいて、燃料電池スタックの内部抵抗値を推定する内部抵抗推定過程と、前記推定された内部抵抗値と予め記憶した標準値との比較に基づいて、燃料電池の湿潤状態を判定する湿潤状態判定過程と、前記湿潤状態判定過程で湿潤が不十分と判定したとき、燃料電池の出力を制限する出力制限過程と、を備えたことを特徴とする燃料電池の運転方法。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】本発明は、固体電解質型の燃料電池及びその運転方法に係り、特に電極や電解質膜の湿度を適切に制御することができる燃料電池及びその運転方法に関する。

## 【0002】

【従来の技術】近年の環境問題、特に自動車の排気ガスによる大気汚染や二酸化炭素による地球温暖化の問題に対して、クリーンな排気及び高いエネルギー効率を可能とする電力源、あるいは動力源として、燃料電池技術が注目されている。

【0003】燃料電池の単セルは、イオン伝導体である電解質膜の両側に触媒を含む電極を接合して構成される。そして2つの電極にそれぞれ燃料ガスと酸化ガス、例えば水素を含むガスと空気とを供給する。水素が供給されるアノード（燃料極）では、水素が水素イオンと電子とに電離する。電子は外部回路を通して陽極に戻り、水素イオンは電解質膜を通してカソード（空気極）に達する。空気中の酸素が供給されるカソードでは、水素イオンと酸素と電子とが反応して水が生成される。

【0004】燃料電池の単セルの理論的な起電力は、約

1. 2Vと低いので、通常複数セルを積み重ねて直列接続としたスタック構造が用いられる。燃料電池の中でも特に高い出力密度を有する固体高分子電解質型燃料電池が自動車等の移動体用動力源として注目されている。

【0005】このような燃料電池の運転において重要な点は、電極触媒及び固体高分子電解質膜の湿潤状態を適正に保つことである。これらが乾燥気味であれば、イオン伝導度が低下し、発電装置としての内部抵抗が増加する。水素と酸素との反応による生成水等により湿潤が過ぎれば、ガスを取り込む有効電極面積が減少して出力電流が減少する。

【0006】従来の燃料電池における電極及び固体高分子電解質膜の湿潤状態を適正に制御する技術として、特開平7-22047号公報記載の技術が知られている。この従来技術によれば、燃料電池内に安定した基準電位を示す参照電極を設け、この参照電極に対するセルのアンード及びカソードの電位を測定し、この電位に基づいて燃料ガスまたは酸化ガスの加湿量を調節していた。

【0007】

【発明が解決しようとする課題】しかしながら、上記従来技術は、燃料電池内の参照電極に対するアンード及びカソードの電位を測定するという構成になっていたため、参照電極を有していない燃料電池には適用ができないという問題点があった。

【0008】また、上記従来技術は、出力電流に対するアンード及びカソード電位の変化により、水分の過剰あるいは膜の乾燥を判定するという構成になっていたため、ある程度以上の出力電流を引き出さないと、特異な反応が見られず、湿潤状態の判定が困難であるという問題点があった。

【0009】さらに、上記従来技術は、アンード及びカソード両極に電位変化の特異性が認められた時、水分の過剰及び膜の乾燥の両方が原因となる可能性があるため、両者の区別に時間がかかる。具体的には一度乾燥状態にし、その電位変化を測定した後に初めて、両者の区別が判定できるため、早急な出力回復が困難であるという問題点があった。

【0010】以上の問題点に鑑み本発明の目的は、燃料電池の各セルに参照電極を設けることなく、湿潤状態を検出して運転を制御できる燃料電池及びその運転方法を提供することである。

【0011】また本発明の目的は、特に燃料電池の出力電流を引き出すことなく、湿潤状態の判定が容易に行える燃料電池及びその運転方法を提供することである。

【0012】さらに本発明の目的は、適正な湿潤状態から水分過剰または乾燥のいずれの方向に変移したかを容易に判定することができる燃料電池及びその運転方法を提供することである。

【0013】

【課題を解決するための手段】請求項1記載の発明は、

上記課題を解決するため、燃料電池スタックを構成する複数のセルから選ばれた少なくとも2つのセルの電圧を検出する電圧検出手段と、少なくとも電圧検出手段によるセル電圧検出時に、燃料電池スタックのセル配列方向に燃料ガス及び酸化ガスの相対湿度分布を形成する湿度分布形成手段と、電圧検出手段が検出した各セル毎の電圧分布を調べて、相対湿度が低いセルの電圧が相対湿度が高いセルの電圧に比べて低い場合に、燃料電池の湿潤が不十分と判定する湿潤状態判定手段と、を備えたことを要旨とする燃料電池である。

【0014】請求項2記載の発明は、上記課題を解決するため、請求項1記載の燃料電池において、前記湿度分布形成手段は、燃料ガス及び酸化ガスの燃料電池スタックへの流入方向と冷却水流入方向とを通常運転時には同方向とする一方、前記湿潤状態判定手段による湿潤状態判定のための前記電圧検出手段による電圧検出時には逆方向に切り替えることで、燃料電池スタックのセル配列方向に燃料ガス及び酸化ガスの相対湿度分布を形成する冷却手段であることを要旨とする。

【0015】請求項3記載の発明は、上記課題を解決するため、請求項1記載の燃料電池において、前記湿度分布形成手段は、燃料ガス及び酸化ガスの燃料電池スタックへの流入方向と冷却水流入方向とを常に逆方向とし、燃料電池スタックのセル配列方向に燃料ガス及び酸化ガスの相対湿度分布を形成する冷却手段であることを要旨とする。

【0016】請求項4記載の発明は、上記課題を解決するため、燃料電池スタック運転中の電圧と電流とを測定する電圧電流測定手段と、この電圧電流測定手段が測定した電圧電流特性に基づいて、燃料電池スタックの内部抵抗値を推定する内部抵抗推定手段と、この推定された内部抵抗値と予め記憶した標準値との比較に基づいて、燃料電池の湿潤状態を判定する湿潤状態判定手段と、を備えたことを要旨とする燃料電池である。

【0017】請求項5記載の発明は、上記課題を解決するため、請求項4記載の燃料電池において、燃料電池の温度を測定する温度測定手段と、測定された温度に基づいて前記標準値を変更する標準値変更手段と、を更に備えたことを要旨とする。

【0018】請求項6記載の発明は、上記課題を解決するため、燃料電池スタックへ流入する燃料ガス及び酸化ガスの水分量を検出する流入水分量検出手段と、燃料電池スタックから流出する燃料ガス及び酸化ガスの水分量を検出する流出水分量検出手段と、燃料電池スタック内部で生成された水分量を推定する生成水分量推定手段と、前記生成された水分量及び流入水分量及び流出水分量に基づいて燃料電池の湿潤状態を判定する湿潤状態判定手段と、を備えたことを要旨とする燃料電池である。

【0019】請求項7記載の発明は、上記課題を解決するため、請求項1ないし請求項6のいずれか1項記載の

燃料電池において、前記湿潤状態判定手段が湿潤が不十分と判定したとき、燃料電池の出力を制限する出力制限手段を更に備えたことを要旨とする。

【0020】請求項8記載の発明は、上記課題を解決するため、燃料電池スタックのセル配列方向に燃料ガス及び酸化ガスの相対湿度分布を形成する湿度分布形成過程と、燃料電池スタックを構成する複数のセルから選ばれた少なくとも2つのセルの電圧を検出する電圧検出過程と、各セル毎の電圧分布を調べて、相対湿度が低いセルの電圧が相対湿度が高いセルの電圧に比べて低い場合に、燃料電池の湿潤が不十分と判定する湿潤状態判定過程と、この湿潤状態判定過程で湿潤が不十分と判定したとき、燃料電池の出力を制限する出力制限過程と、を備えたことを要旨とする燃料電池の運転方法である。

【0021】請求項9記載の発明は、上記課題を解決するため、燃料電池スタック運転中の電圧と電流とを測定する電圧電流測定過程と、この測定された電圧電流特性に基づいて、燃料電池スタックの内部抵抗値を推定する内部抵抗推定過程と、この推定された内部抵抗値と予め記憶した標準値との比較に基づいて、燃料電池の湿潤状態を判定する湿潤状態判定過程と、この湿潤状態判定過程で湿潤が不十分と判定したとき、燃料電池の出力を制限する出力制限過程と、を備えたことを要旨とする燃料電池の運転方法である。

【0022】

【発明の効果】請求項1記載の発明によれば、燃料電池スタックを構成する複数のセルから選ばれた少なくとも2つのセルの電圧を検出する電圧検出手段と、少なくとも前記電圧検出手段によるセル電圧検出時に、燃料電池スタックのセル配列方向に燃料ガス及び酸化ガスの相対湿度分布を形成する湿度分布形成手段と、前記電圧検出手段が検出した各セル毎の電圧分布を調べて、相対湿度が低いセルの電圧が相対湿度が高いセルの電圧に比べて低い場合に、燃料電池の湿潤が不十分と判定する湿潤状態判定手段と、を備えたので、相対湿度が高いセルの電圧と相対湿度の低いセルの電圧の測定結果に基づいて燃料電池の湿潤状態が水分過剰か水分不足かを正確に判定することができるという効果を奏する。また湿潤状態の判定が正確になるので、不要な水素パージを低減し、燃料電池の燃費を向上するという効果を奏する。

【0023】請求項2記載の発明によれば、請求項1記載の発明の効果に加えて、前記湿度分布形成手段は、燃料ガス及び酸化ガスの燃料電池スタックへの流入方向と冷却水流入方向とを通常運転時には同方向とする一方、前記湿潤状態判定手段による湿潤状態判定のための前記電圧検出手段による電圧検出時には逆方向に切り替えることで、燃料電池スタックのセル配列方向に燃料ガス及び酸化ガスの相対湿度分布を形成する冷却手段であるとしたので、通常運転時に好適な相対湿度分布と湿潤状態判定時に好適な相対湿度分布との双方の相対湿度分布を

形成し、通常運転時の発電効率を低下させることなく、正確な湿潤状態の判定を行うことができるという効果を奏する。

【0024】請求項3記載の発明によれば、請求項1記載の発明の効果に加えて、前記湿度分布形成手段は、燃料ガス及び酸化ガスの燃料電池スタックへの流入方向と冷却水流入方向とを常に逆方向とし、燃料電池スタックのセル配列方向に燃料ガス及び酸化ガスの相対湿度分布を形成する冷却手段であるとしたので、冷却水流入方向切り替え機能を設けて冷却手段を複雑にすることなく、正確な湿潤状態の判定を行うことができるという効果を奏する。

【0025】請求項4記載の発明によれば、燃料電池スタック運転中の電圧と電流とを測定する電圧電流測定手段と、該電圧電流測定手段が測定した電圧電流特性に基づいて、燃料電池スタックの内部抵抗値を推定する内部抵抗推定手段と、前記推定された内部抵抗値と予め記憶した標準値との比較に基づいて、燃料電池の湿潤状態を判定する湿潤状態判定手段と、を備えたので、燃料電池スタックに相対湿度分布を形成することなく、湿潤状態を判定することができるという効果を奏する。

【0026】請求項5記載の発明によれば、請求項4記載の発明の効果に加えて、燃料電池の温度を測定する温度測定手段と、測定された温度に基づいて前記標準値を変更する標準値変更手段と、を更に備えたので、燃料電池の運転温度に変化があっても正確な湿潤状態判定を行うことができるという効果を奏する。

【0027】請求項6記載の発明によれば、燃料電池スタックへ流入する燃料ガス及び酸化ガスの水分量を検出する流入水分量検出手段と、燃料電池スタックから流出する燃料ガス及び酸化ガスの水分量を検出する流出水分量検出手段と、燃料電池スタック内部で生成された水分量を推定する生成水分量推定手段と、前記生成された水分量及び流入水分量及び流出水分量に基づいて燃料電池の湿潤状態を判定する湿潤状態判定手段と、を備えたことにより、燃料電池スタック内部の水分量の変化履歴を正確に追跡し、燃料電池の湿潤状態を正確に判定することができるという効果を奏する。

【0028】請求項7記載の発明によれば、請求項1ないし請求項6記載の発明の効果に加えて、前記湿潤状態判定手段が湿潤が不十分と判定したとき、燃料電池の出力を制限する出力制限手段を更に備えたので、燃料電池の乾燥状態からの回復と運転継続とを両立させることができるという効果を奏する。

【0029】請求項8記載の発明によれば、燃料電池スタックのセル配列方向に燃料ガス及び酸化ガスの相対湿度分布を形成する湿度分布形成過程と、燃料電池スタックを構成する複数のセルから選ばれた少なくとも2つのセルの電圧を検出する電圧検出過程と、各セル毎の電圧分布を調べて、相対湿度が低いセルの電圧が相対湿度が

高いセルの電圧に比べて低い場合に、燃料電池の湿潤が不十分と判定する湿潤状態判定過程と、前記湿潤状態判定過程で湿潤が不十分と判定したとき、燃料電池の出力を制限する出力制限過程と、を備えたので、相対湿度が高いセルの電圧と相対湿度の低いセルの電圧の測定結果に基づいて燃料電池の湿潤状態が水分過剰か水分不足かを正確に判定することができるという効果を奏する。また湿潤状態の判定が正確になるので、不要な水素パージを低減し、燃料電池の燃費を向上するという効果を奏する。

【0030】請求項9記載の発明によれば、燃料電池スタック運転中の電圧と電流とを測定する電圧電流測定過程と、前記測定された電圧電流特性に基づいて、燃料電池スタックの内部抵抗値を推定する内部抵抗推定過程と、前記推定された内部抵抗値と予め記憶した標準値との比較に基づいて、燃料電池の湿潤状態を判定する湿潤状態判定過程と、前記湿潤状態判定過程で湿潤が不十分と判定したとき、燃料電池の出力を制限する出力制限過程と、を備えたので、燃料電池スタックに相対湿度分布を形成することなく、湿潤状態を判定することができるという効果を奏する。また湿潤状態の判定が正確になるので、不要な水素パージを低減し、燃料電池の燃費を向上するという効果を奏する。

#### 【0031】

【発明の実施の形態】次に、図面を参照して、本発明の実施の形態を詳細に説明する。

【第1の実施形態】図1は、本発明に係る燃料電池の第1の実施形態の構成を説明する全体構成図である。図1において、燃料電池は、燃料ガスとしての水素を含むガス（以下、水素含有ガス）を所望の圧力・流量で供給する水素供給部1と、酸化ガスとしての空気を所望の圧力・流量で供給する空気供給部2と、図示しない純水供給器から供給される純水で水素含有ガスと空気とをそれぞれ加湿する加湿器3と、加湿器3で加湿された水素含有ガス及び空気が供給される燃料電池スタック4と、使用されなかった水素を再循環させる燃料循環用ポンプ5と、水素含有ガスの逆流を防止する逆止弁6と、燃料電池スタック4を冷却するとともに、湿潤状態判定のための電圧測定時には燃料電池スタック4への冷却水の流入方向を燃料電池スタック4へのガス流入方向とは逆方向とすることができる冷却系12と、これらの装置を制御する制御装置11とを備えている。

【0032】燃料電池スタック4には、スタックを構成する複数のセルから選ばれた2つ以上のセル、好ましくは全てのセルのそれぞれの電圧を検出する電圧検出手段である図示しない電圧検出器が設けられ、この電圧検出器の検出信号は、制御装置11へ伝えられるようになっている。

【0033】冷却系12は、燃料電池スタック4の内部に設けられた図示しない冷却水流路と、冷却水を循環さ

せる冷却水ポンプ7と、冷却水の熱を外部へ放熱するラジエータまたはラジエータとラジエータファンの組8と、燃料電池スタック4に流れる冷却水の方向を反転させる4方弁9と、冷却水温度を測定する温度計10と、これらを接続する管路と、これらの内部に充填された冷却水とを備えている。

【0034】そして、冷却系12は、電圧検出手段によるセル電圧検出時に、燃料電池スタックのセル配列方向に燃料ガス及び酸化ガスの相対湿度分布を形成する湿度分布形成手段を構成している。

【0035】また制御装置11は、水素供給部1、空気供給部2及び温度計10からの検出信号を受信する一方、水素供給部1、空気供給部2、冷却水ポンプ7、4方弁9を制御する制御信号を送出するようになっている。

【0036】次に、冷却系12による相対湿度分布形成の作用について説明する。水素供給部1及び空気供給部2から供給される水素含有ガス及び空気は、加湿器3を通過し、適当な湿度となった後、燃料電池スタック4の図中右側から供給される。この水素含有ガス及び空気は、加湿器3によりある絶対湿度に加湿された後、燃料電池スタック4の内部を右から左へ流れるに従って、発電により生成する水分により更に加湿されるので、絶対湿度が下がることはなく、寧ろ絶対湿度が上がると考えられる。

【0037】冷却水方向を切り替える4方弁9は、制御装置11からの制御に従って、通常運転時には実線の矢印方向に冷却水を流し、電圧検出器による電圧検出時には、破線の矢印方向に冷却水を流すように切り替える。これにより燃料電池スタック4を流れる冷却水は、通常運転時には図中右から左へ流れるので、この時の燃料電池スタック4内の温度分布は、図中右側が低く、左側が高くなる。

【0038】一方、湿潤状態判定のための電圧測定時には、ガスの流れる方向とは反対に図中左から右へ冷却水が流れるので、この時の燃料電池スタック4内の温度分布は、通常運転時とは反対に図中右側が高く、左側が低くなる。従って、電圧測定時の燃料電池スタック4の相対湿度分布は、図中右側が低く、左側が高くなる。

【0039】このような相対湿度分布を形成した状態で、燃料電池スタック4の複数セルのそれぞれの温度を測定すると、測定されたセルの位置に応じて、相対湿度の低いセルの電圧と、相対湿度の高いセルの電圧とを測定することになる。

【0040】尚、第1実施形態の変形例として、通常運転時と湿潤状態判定のための電圧測定時とで冷却水方向を切り替えることなく、常に燃料電池スタックへのガス流入方向と冷却水入流方向とを反対方向として、燃料電池スタックに相対湿度分布が形成されるようにしてもよい。この変形例によれば、冷却水方向を切り替える4方



弁を省略して、図2に示す構成となるが、通常運転時の発電効率に多少の低下が生じるのはやむを得ない。

【0041】次に、第1実施形態の動作を図3のフローチャートを参照して説明する。まずステップ（以下、ステップをSと略す）101で燃料電池スタック運転中の電流及び電圧の検出を行う。次いでS102では、この検出された電流／電圧の組み合わせが予め記憶してある電流電圧特性より電圧低下しているかの判定を行い、電圧低下が認められなければ、S103以下に示した本実施形態の処理フローを実施することなく、再びS101へと戻る。

【0042】電圧低下が認められた時は、電圧を適切に回復すべく、電圧低下の原因を精度よく判定する必要があるとし、本実施形態ではS103で水素や空気といったガスの燃料電池スタック4への入出力方向とは逆方向に冷却水の循環方向がなるように4方弁9を切り替える。この冷却水流入方向の切替により、燃料電池スタック4内には、上述のようにセル配列方向に相対湿度の分布が形成される。

【0043】尚、図2に示した第1実施形態の変形例のように、燃料電池スタックへの冷却水の流入方向を常にガスの流入方向とは逆方向に設定され、冷却水流入方向を切り替えない構成となっている場合には、このS103は省略される。

【0044】また、S102では電圧低下の有無を判定し、電圧低下が判定されたときに本ステップ以下を実行するとしているが、S101、S102を削除して、S103以下の処理を定期的に行う構成としてもよい。

【0045】次いで、セル配列方向に相対湿度の分布が形成された状態で、S104で燃料電池スタックを構成する各セルの電圧を電圧検出器で検出し、検出値を制御装置11へ伝える。燃料電池スタック4は複数のセルから構成されるが、これら複数個のセル電圧はできるだけ同一時刻の値を検出できる構成とした方が望ましい。

【0046】次いで、S105では、各セルの位置によるセル電圧の傾向を判定し、S106で、電圧低下の原因が膜の乾燥によるものであるか否かを判定する。

【0047】図4は、各セル位置に対応するセル電圧分布の一例であるが、ガス入口側から出口側に向かって各セルの電圧を順番に並べて表現した図である。この図4のように、ガス入口側から出口側にかけてセル電圧が高くなるような傾向が得られた場合には、膜が十分に湿潤しておらず乾燥状態にあると判断を行う。

【0048】これは、相対湿度の低い部分のセルの電圧が、相対湿度の高いセルの電圧より低いことを意味しており、即ち相対湿度の低い部分のセルの膜が十分に湿潤しておらず、電圧の低下の原因となっていると判断することが可能である。

【0049】また図5に示すようなセル電圧分布が得ら

れた場合、即ち相対湿度の分布とセル電圧の分布とに特に相関が見られない場合であるが、この場合には膜は十分に湿潤していると判断する。セル電圧と相対湿度に相関がない状態では、もしセル電圧が期待値よりも低いとしても、膜が乾燥しているのではなく、他の原因、例えば水素分圧の低下等によるものと判断してよい。

【0050】尚、本実施形態において図6に示すような分布が得られた場合、即ちガス入口側の相対湿度の高い部分のセル電圧が、ガス出口側の相対湿度の低い部分のセル電圧に対して低いような分布が得られた場合であるが、この場合には、相対湿度の高い部分のセルに水分が貯まり、反応面積の低減により電圧が低下していると判断が可能である。

【0051】以上のように、電圧低下の原因が膜の乾燥によるものと判断された場合、燃料電池スタック出力を制限し、スタック電圧がある設定値以下にならないように制御する（S107～109）、と同時に、燃料電池制御手段11へ燃料電池スタックの出力要求を指令する上位の制御手段（図示せず）に、出力要求可能な上限値を通知する。

【0052】これにより上位の制御手段は、燃料電池スタックの出し得る電力の最大値を認識しつつ、要求指令値の演算が可能になるので、予想外に出力されないという状態を防止することができる。

【0053】尚、燃料電池スタックの出力制限は、S104～S106のように各セル電圧の位置に応じた傾向により膜の湿潤状態を推定した結果によって行ってもよい。

【0054】また、燃料電池スタックの電圧や出力の制御手段であるが、電流制御機能付きのDC/DCコンバータを燃料電池スタックに接続して実施してもよく、詳細については省略する。

【0055】また、電圧低下の原因が膜の乾燥以外であった場合には、その原因に対応した処理を行うブロックを実行する。例えば水素極側において窒素濃度が上がり、その結果水素分圧が低下しているような場合には、水素極をバージすることで水素分圧を上げるように制御を行う（S110）。

【0056】一例としては、水素が循環系である場合には、燃料電池スタックからの排水素を戻すことなくシステム外部に排出し、また同時に水素流量を増大させることで水素極バージが可能であるが、本発明の本質でないもので、詳細は省略する。

【0057】〔第2の実施形態〕本実施形態の構成は第1の実施形態を示す図1と同一である。尚、本実施形態においては、ガスの流入方向と冷却水の流入方向を必ずしも逆にする必要はないので、4方弁9を省略することができる。

【0058】図7に本実施形態のフローチャートを示す。本実施形態は燃料電池スタックの運転中の電流及び



電圧をある定まった時間以上、あるいは、ある定まったサンプリング数以上測定し、測定された電流及び電圧から内部抵抗値を演算し、その値から膜の乾燥状態を推定するものである。

【0059】ここでいう内部抵抗値とは図10(a)に示す電流－電圧特性における中間部分の傾きに相当する。膜の水分量が減少するに従い、イオン伝導度が低下し、電気抵抗の増大のような形で観測される。

【0060】即ち、十分湿潤していれば、図10(a)における最も高い電圧を示す特性（以下、標準特性とする）となるが、乾燥気味になるにつれ、同じ電流値を燃料電池スタックから引き出した時の電圧が低下し、略直線部の傾きが急となり、結果、電流－電圧特性は左下のような形へと推移することになる。

【0061】またこの略直線部の傾きが標準特性のそれと同じであるが、ある電流値以上を取り出した時のみ、急激に電圧の低下が認められた場合（図10

(b)）は、膜の湿潤状態は適当だが、ガス（流量や圧力）が取り出した電流に対して適切ではないと判断を行う。

【0062】また図10(a)と図10(b)の状態が同時に発生する場合には、図10(c)に示すような電圧電流特性となり、略直線部の傾きが標準特性より急で、かつ、ある電流値以上を取り出した時、特性が直線から外れて電圧が低下した場合には、膜の湿潤が不足気味であり、かつ、ガス（流量や圧力）の状態が適切でないと判断することができる。

【0063】以下に、燃料電池スタックの運転中に測定された電圧電流特性に基づいて内部抵抗を求める図7のフローチャートを説明する。

【0064】まずS201で略同時刻の燃料電池スタックの電流及び電圧を検出する。このタイミングはできるだけ同時刻の方が望ましい。次いでS202では検出した電流の値によってデータのフィルタリングを行う。これは極小電流域での特性は内部抵抗の影響が出ていない為、そのような領域のデータをカットする為である。S203では、後述する内部抵抗演算で参照するために、測定した電流及び電圧の組データを記録手段に記録する。

【0065】S204では、記録された電流及び電圧の組データが、内部抵抗算出に十分なものであるかを判定する。十分と判定する条件として、電流値が広範囲に十分散らばっていること、組データ数がある設定値以上記録されていること、等がある。S205では実際に内部抵抗を演算する。具体的には複数個の電流及び電圧の組データを直線で近似し、その直線の傾きから求める。

【0066】尚、複数個の電流／電圧の組データを直線で近似する方法については、各組データを示す点から近似直線までの距離の2乗の合計が最小となる近似直線を求める最小2乗法や、例えば特開平6-174808号

公報に示された方法等がある。

【0067】以上のような方法で求めた略直線部の傾きと、予め実験等で求めておいた標準特性とを比較し、傾きが急な場合には膜が乾燥していると判断し、出力の制限を行う等の処理を行い、スタックの劣化等悪影響を抑えることが可能となる。また略直線部の傾きが、標準特性のそれと略同一で、ある電流値以上の場合に電圧の低下が認められる時は、ガス条件に問題があるとし、パージ処理を行うことで水素極に蓄積された窒素を排出し、水素分圧を回復し、電圧の標準特性に戻すことが可能となる。

【0068】尚、燃料電池の内部抵抗は、電極の抵抗、電解質のイオン導電度等、温度特性を有するので、例えば冷却水温を測定する温度計10の測定結果に応じて、内部抵抗の標準値を変更することが好ましい。具体的には、実験的に求めたマップや、補正計算式を用いる。

【0069】〔第3の実施形態〕図8は、本発明に係る燃料電池の第3の実施形態の構成を示す全体構成図である。本実施形態は、図1に示した第1の実施形態に対し、4方弁9を削除して燃料電池スタック4への冷却水流入方向をガス流入方向と常に同一とし、水素含有ガス及び空気の燃料電池スタック入出力部に水分流量検出手段を設けた例である。

【0070】即ち燃料電池スタック4へ水素供給部1から流入する水分流量を検出する水分流量検出手段21と、水素出口から流出する水分流量を検出する水分流量検出手段22と、空気供給部2から流入する水分流量を検出する水分流量検出手段23と、空気出口のから流出する水分流量を検出する水分流量検出手段24とを設けている。これらの水分流量検出手段21、22、23、24としては、例えば鏡面冷却式等の露点検出手段と、質量流量検出手段で構成することが可能である。

【0071】また制御装置11では、燃料電池スタック4から取り出した電流値に応じて燃料電池スタック内部で生成された水分量を演算する手段が設けられている。

【0072】燃料電池スタック4の入口の水素及び空気中の水分流量合計にスタック内部で生成された水分量を加えた値に対し、燃料電池スタック出口の水素及び空気中の水分流量合計が大きければ、膜から水分のガス中に出ていることを示し、即ち膜が乾燥傾向にあることを示している。

【0073】逆に出口の水素及び空気中の水分量合計が小さければ、膜にガス中から水分が浸透していることになり、即ち膜が湿潤傾向にあることがわかる。よって、この水分の変化量を積分することにより燃料電池スタック内の平均的湿潤程度を推定することができるようになる。

【図面の簡単な説明】

【図1】本発明に係る燃料電池の第1の実施形態の構成を示す全体構成図である。

【図2】第1実施形態の変形例の構成を示す全体構成図である。

【図3】第1の実施形態の動作を説明するフローチャートである。

【図4】不十分な湿潤状態におけるセル位置に対するセル電圧分布例を示す図である。

【図5】適度な湿潤状態におけるセル位置に対するセル電圧分布例を示す図である。

【図6】過剰な湿潤状態におけるセル位置に対するセル電圧分布例を示す図である。

【図7】第2の実施形態の動作を説明するフローチャートである。

【図8】本発明に係る燃料電池の第3の実施形態の構成を示す全体構成図である。

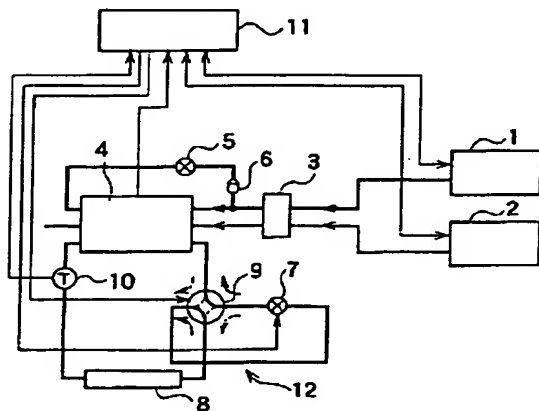
【図9】(a) 膜中の水分が減少した場合、(b) 水素分圧が低下した場合、(c) 膜中の水分が減少した状態

で水素分圧が低下した場合のそれぞれ燃料電池の電流－電圧特性の代表例を示す図である。

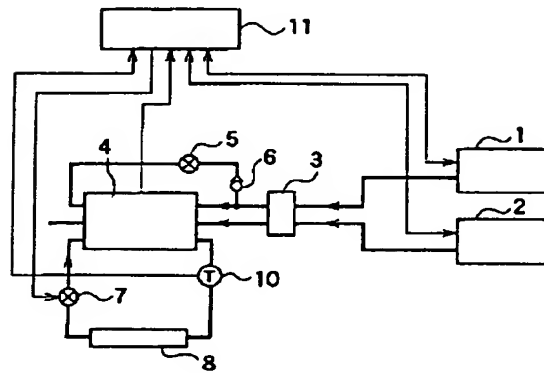
【符号の説明】

- 1 水素供給部
- 2 空気供給部
- 3 加湿器
- 4 燃料電池スタック
- 5 燃料循環用ポンプ
- 6 逆止弁
- 7 冷却水ポンプ
- 8 ラジエータ
- 9 4方弁
- 10 温度計
- 11 制御装置
- 12 冷却系

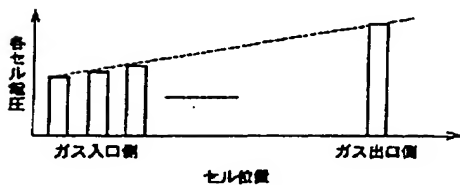
【図1】



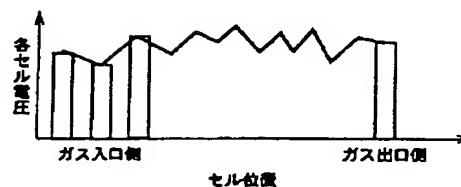
【図2】



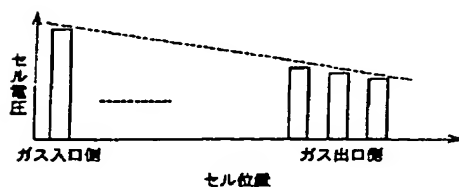
【図4】



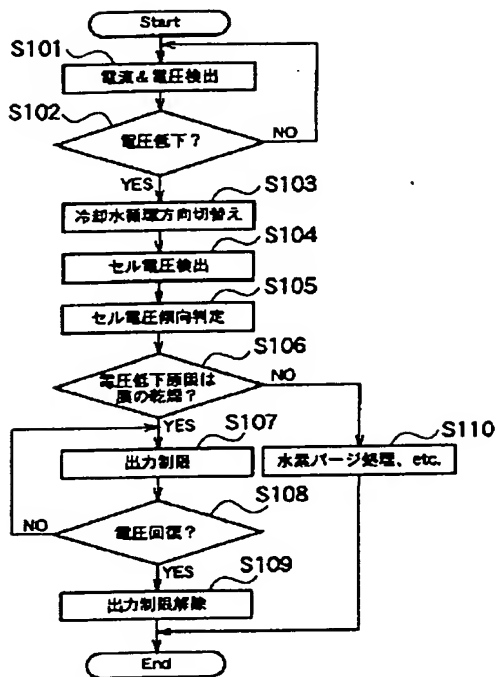
【図5】



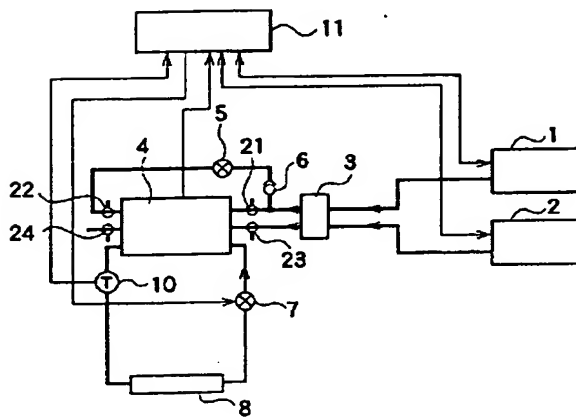
【図6】



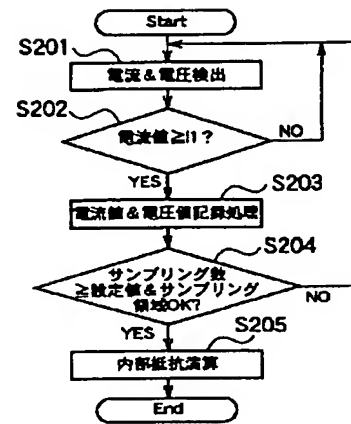
【図3】



【図8】



【図7】



【図9】

